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Evaluation of injection pressure as a process fingerprint for Injection and Injection Compression Molding of micro structured optical components

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Abstract

Injection pressure is one of the most significate factor governing the effectiveness of Molding based manufacturing processes. Being the monitoring of injection pressure easy to implement, the opportunity to address quality control on injection pressure as manufacturing fingerprint opens up to the possibility of implementing online process control solutions for Industry 4.0 approaches; examples are machine learning, deep learning and artificial intelligence. For the purpose, the calibration of process fingerprints with a quality feature of the final part is required. In this study, the injection pressure is assessed in different Injection Molding and Injection Compression Molding process conditions when replicating a polymer microstructured optical part [1]. The study case presents a high clarity polymer Fresnel lens showing a square aperture with varying low aspect ratio features. Grooves step height size ranges from 17.3 µm to 346.6 µm for peak-to-valley (PV) while the pitch has a constant value of 748.1 µm. Absolute dimensions of the grooves, as long as global part mass, are investigated in varying compression gap and holding pressure levels. Defining relationship between the geometrical dimensions of the micro structures, global mass and process fingerprint is the main outcome of this research work.

Injection Compression Moulding, Injection Pressure, Manufacturing signatures, Fresnel Lenses

Injection Compression Moulding (ICM)

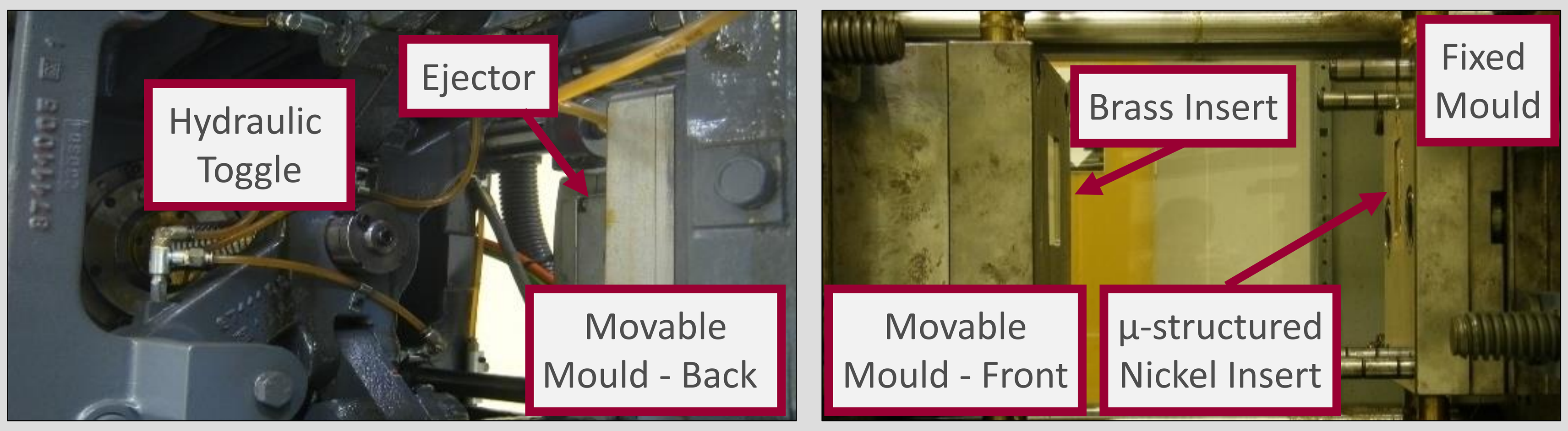

Fig. 1: Toggle clamp unit of the ICM machine (left) and moulds in open position (right)

Injection Pressure as a process fingerprint

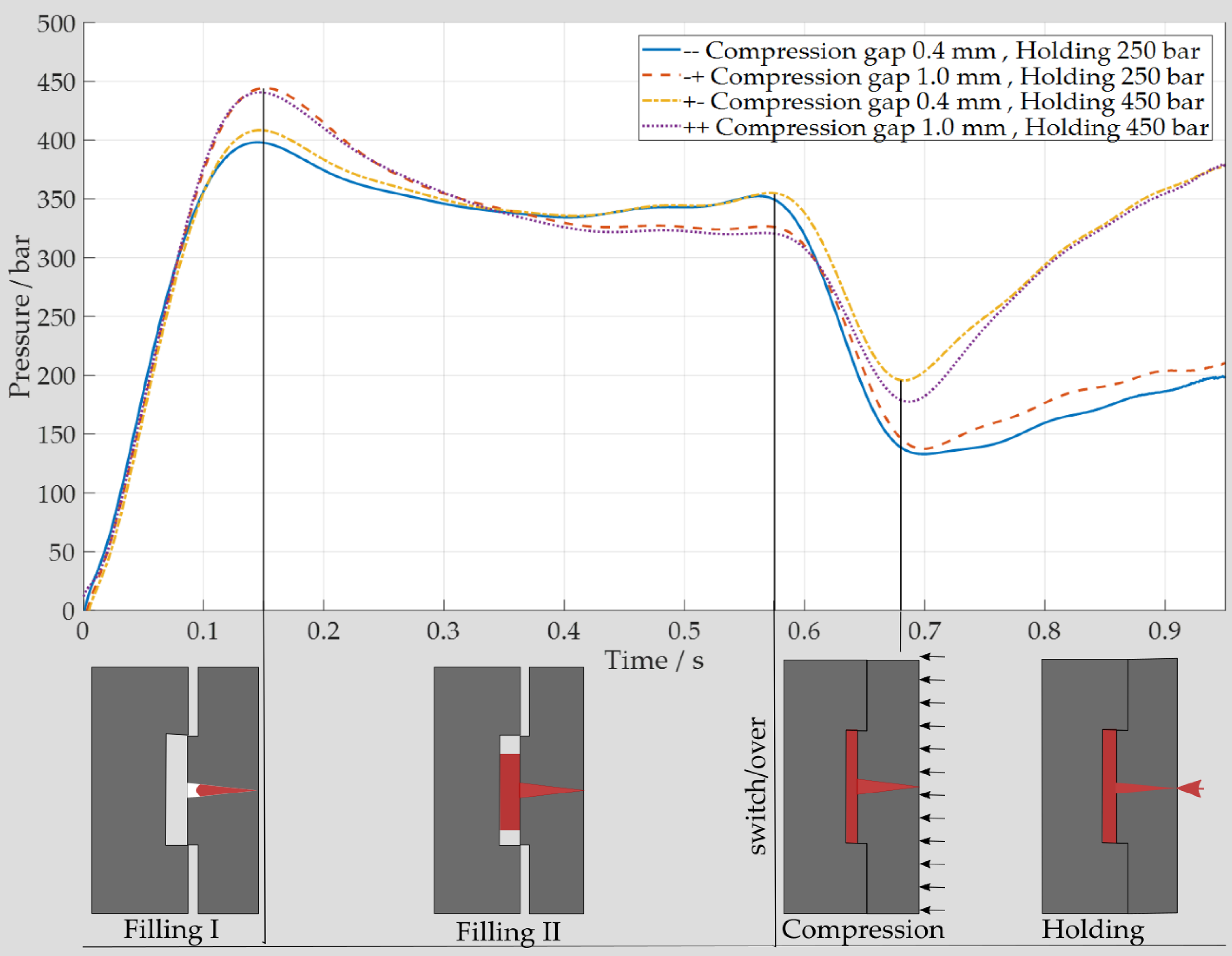

Fig. 2: Injection Pressure of ICM with different compression gap and holding pressure levels

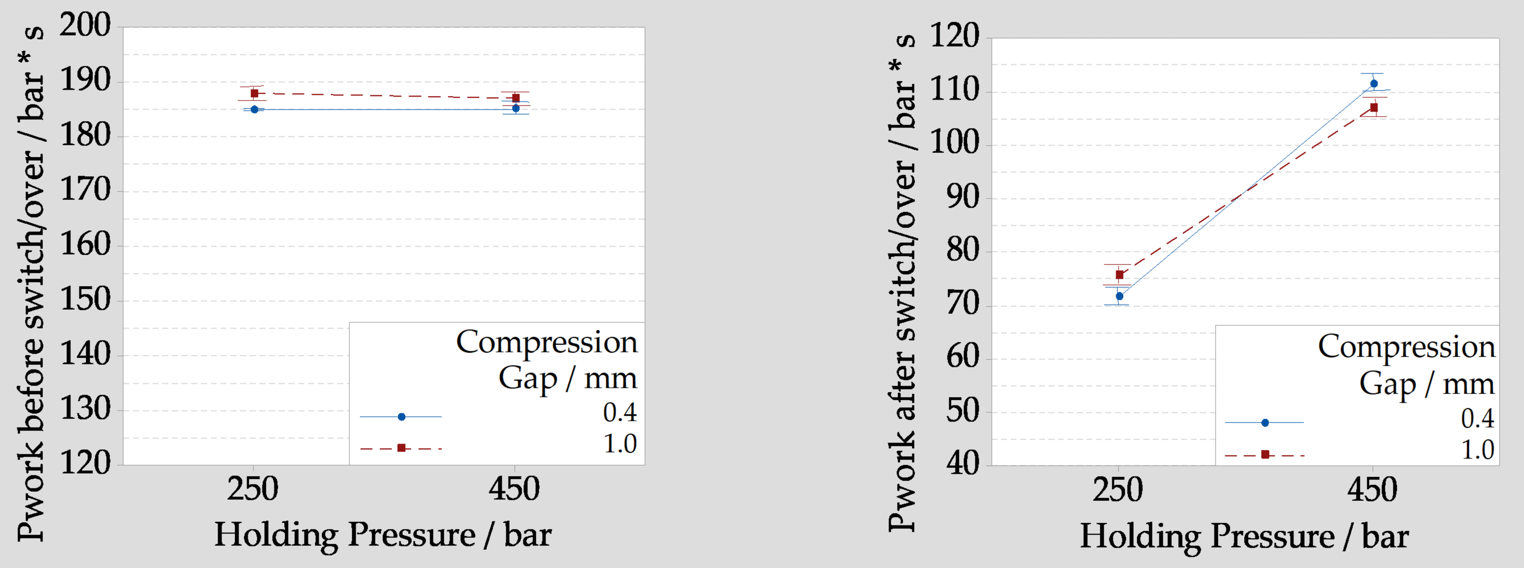

Fig. 3: Interactions plot of holding pressure and compression gap before (left) and after (right) the switch-over control point on the integral of Injection Pressure on time (P_{work})

Microstrucutred optical Fresnel lens design

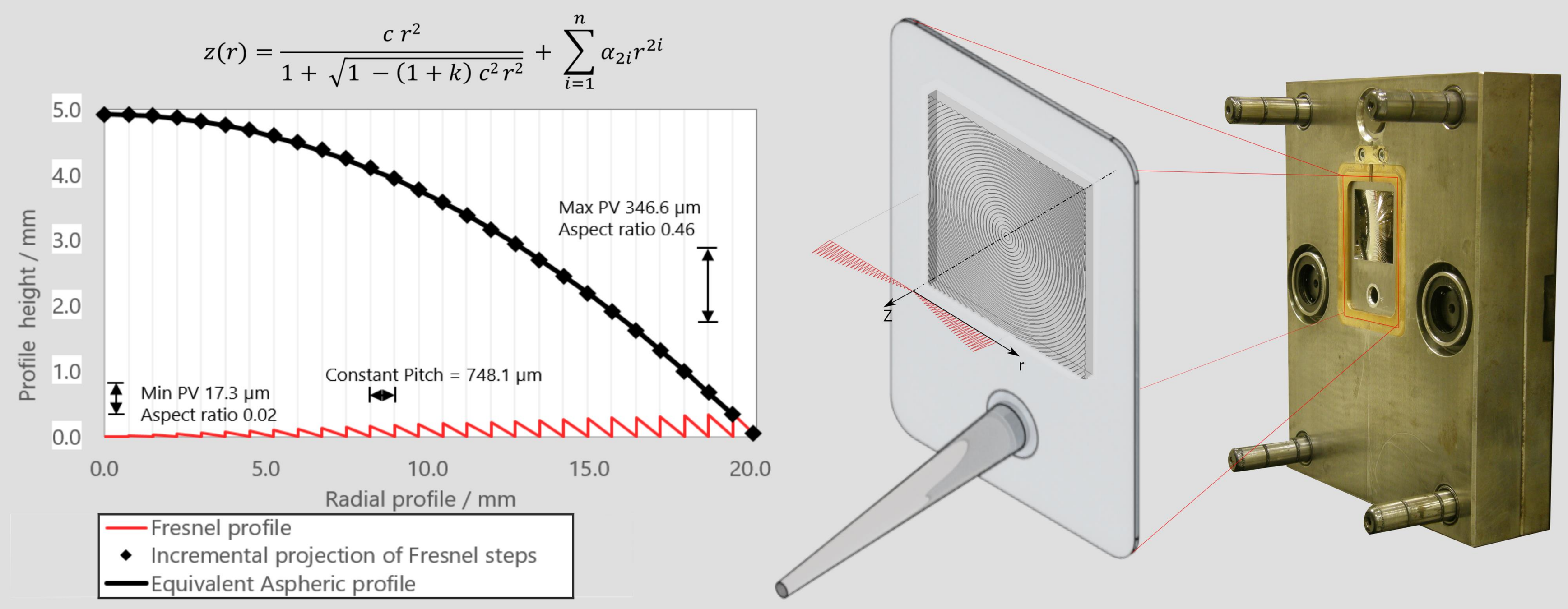

Fig. 4: Micro structured polymer (COC – Zeonex® E48R) Fresnel lens design [2-3]

Measurements results and comparison

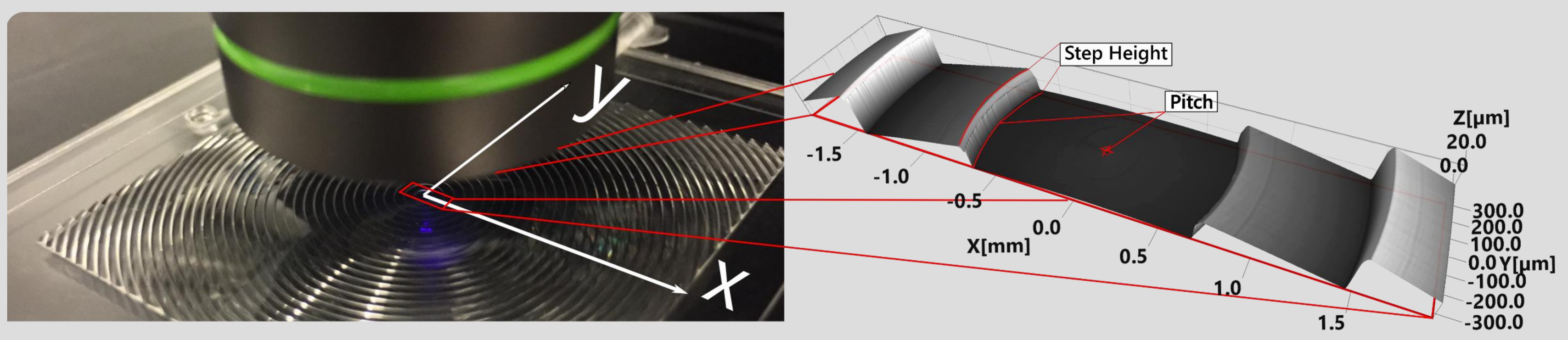

Fig. 5: Measuring the central area of the Fresnel lens [4-5]

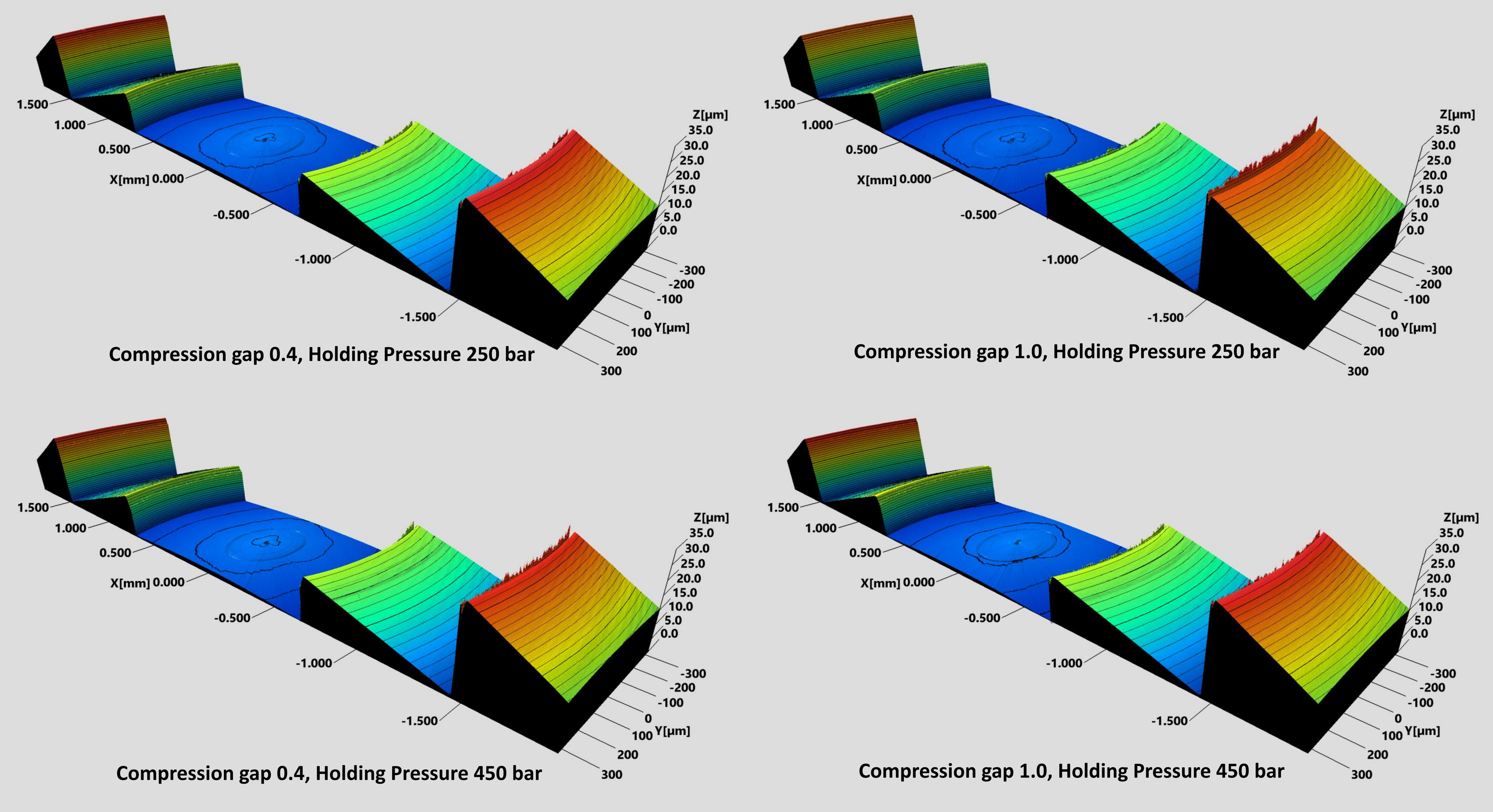

Fig. 6: Manufacturing signature depending on two compression gap and holding pressure levels

Conclusion

The compression phase led to a pressure cavity variation over time both during and after the filling phase. However, the main driver of the pressure variation during the filling phase was the compression gap while its effect during the holding phase was overcome by the holding pressure. P_{work} was used as an indicator of the energy transferred to the polymer part during processing and its calibration served as a production manufacturing signature.

Acknowledgements

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